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Review Article

A critical review on neonatal hyperbilirubinemia-an ayurvedic perspective

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ABSTRACT

Neonatal hyperbilirubinemia is the elevation of the bilirubin level in the newborns blood, which results in yellowish staining of the skin and sclera of the newborn eyes by pigment of bile. It is due to the breakdown of RBC's (which release bilirubin into the blood) and the immaturity of newborns liver (which cannot effectively metabolize the bilirubin and prepare it for excretion into the urine). Increased bilirubin production, reduced hepatic clearance and enhanced enterohepatic circulation are the sole causes of increased prevalence of jaundice in newborn. The science of *Ayurveda* is supposed to add a step in order to understand the pathophysiology of neonatal jaundice that have resemblance with clinical entity of *kamala* (jaundice) mentioned in *Kashyapa Samhita*. The concept of neonatal hyperbilirubinemia in *Ayurveda* can be understood in the context of *Pittaja stanya dushti* along with the physiological variations in the newborns leading to the raised level of unconjugated bilirubin. Therefore, the patho-physiology should be known by a pediatrician in *Ayurveda* based on the involvement of *dosha*, *dhatu*, *mala* and *srotas*. Hence, an attempt is made in this review to discuss about the hidden concept of pathology of neonatal jaundice described in *Ayurveda*. These findings to understand the concept of neonatal jaundice in *Ayurveda* add up to the *Ayurvedic* science that has been developed through ages.

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1. Introduction

Newborn have unique health issues and problem due to structural and functional immaturity of various body organs depending upon their gestational age and birth weight [1]. Jaundice is the most common abnormal finding in neonates. About 60% of term and 80% of preterm babies develop jaundice in the first week of life. Untreated severe hyperbilirubinemia often signifies a serious illness [2]. Unconjugated bilirubin can cross the blood brain barrier due to many factors. These include alterations in the bilirubin binding capacity of albumin and other proteins and disruption of the blood brain barrier due to underlying conditions like asphyxia, acidosis etc. It is due to physiological polycythemia, shorter lifespan of RBC (90 days vs 120 days in adults), limited hepatic uptake, conjugation and excretion of bilirubin due to transient deficiency of receptor proteins and UDGPT enzymes in newborn especially in premature.

It is also due to paucity of bacterial flora in the gut and over activity of beta glucuronidase enzyme in the newborn. In India, physiological jaundice, immaturity, blood group incompatibility, antenatal and postnatal infections, G-6PD deficiency and breastmilk jaundice are the causes of order of incidence of neonatal jaundice. Higher prevalence of jaundice is due to increased bilirubin production, reduced hepatic clearance and enhanced enterohepatic circulation in newborn. Increased bilirubin production can overwhelm the normal buffering capacity of the blood and result in the production of bilirubin acid, which is highly neurotoxic. It may cause transient encephalopathy and kernicterus which may progress over 24 h to 7 days [3].

The broad aim of this article is to provide a general outline on the description of neonatal hyperbilirubinemia from Ayurvedic perspective. This article reviews the available literature to understand the pathological changes and its manifestations in relation to neonatal hyperbilirubinemia through *Ayurveda*. It is written with an intention to create awareness and implement the principles mentioned in the ancient texts, suggesting an integrated approach in its management and treatment.

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2. Analysis of neonatal hyperbilirubinemia in Ayurveda

By looking on to the signs and symptoms of the neonatal jaundice, it can be considered similar as that of the features of *Kamala* explained by *Kashyapa Acharya* in *Kashyapa samhita*.

The Signs and symptoms of *Kamala* related to *shishu* (infant) are described in *Vedana Adhyaya*, *Sutrasthana*, *Kashyapa Samhita* are considered to be an exclusive texts on pediatrics in *Ayurveda*. *Vedana Adhya* is written by *Vruddha Jeevaka* after he prayed to Lord *Kashyapa* to explain the features an infant will show, when he is not able to express his pain, for the diagnosis of various diseases [4] (How a physician should know, only on the basis of clinical features, about various pains children's who cannot narrate the symptoms.)

2.1. Historical review

Rigveda: *Rigveda* in one of its hymn, mentioned prayer of *Surya* (Sun God) referring to the submission to remove *Hariman* ie; to remove yellowish pigmentation and make the complexion normal.

Atharvaveda: *Ayurveda* is the *Upaveda* of *Atharvaveda*. In *Atharvaveda*, *Kamala* was known by the name *Harima* – It is so because all the body parts become *Haridravarna* (yellowish) in *Kamala vyadhi* (jaundice). *Atharvaveda* suggest *Surya kirana snana* (exposure to sunlight) for *Kamala* as described in *Suryakirana chikitsa prakarana* of *Atharvaveda*. Here sunlight function on the body to remove yellowish discoloration of the body as similar to that of phototherapy described in modern science for neonatal jaundice [5].

2.2. Disease review

Acharya Charaka has described the disease *Kamala* (jaundice) under the chapter of '*Panduroga chikitsa upakrama*' [6]. *Acharya* mentioned different *nidanans* (causes), *bheda* (types), *lakshanas* (symptoms) and *Chikitsa* (treatment) for the disease *Kamala*. *Kamala* related to *Balaka* (infant) is due to ingestion of *Dushta Sthanya* (vitiated breast milk) described in *Charaka Samhita*⁷¹ and *Madhava nidana* [7] (Table 2).

In *Ashtang Hridaya sutrasthana*, disease *Kamala* is formed due to increased *rakta dhatu* (blood plasma) [8] (Table 1).

There is a detail explanation of *nidana* (causes), *chikitsa* (treatment), *lakshana* (symptoms) of *kamala vyadhi* (jaundice) in *Yogar-atnakara* text. For the first time, there is an explanation of *dronpushpi swarasa anjana* (eye application) in *kamala* [9]. The above text also provided an explanation regarding *stanya dushti* (vitiation of breast milk) by various *doshas* (bodily humors) and their symptoms with management, where the author described *Kamala* as a symptom of *pittaja stanya dushti* (breast milk vitiated by *Pitta*). Under the same, *Acharya* explained the use of *Guduchi*, *Shatavari*, *Patola patra*, *Nimba twak* and *Raktachandana* processed with *sharkara* in *pittaja stanya dushti* to mother and child [9].

Acharya Kashyapa described the *Lakshana* of *Kamala Vyadhi* (symptoms of jaundice) related to *balaka* (infant) in *Vedana Adhyaya*, *Sutrasthana* of *Kasyapa Samhita*. But the *Nidana* (causes), *Samprapti* (pathogenesis) and *Chikitsa* (treatment) are not been mentioned in *Kashyapa Samhita*.

Table 1
Showing *dhatu parinaama* (tissue formation).

Fuel	Dhatwagni	Prasada paka (essence)		Kittapaka (waste)
		Sthula bhaga	Sukshma bhaga	
Poshaka Rasa	Rasagni	Poshya Rasa	Rakta	Malrupa Kapha
Poshaka Rakta	Raktagni	Poshya Rakta	Mamsa	Malarupa Pitta

The symptomatology of *Kamala* is quite similar with jaundice of neonates, as this *grantha* (book) is uniquely described for Pediatrics. *Kashyapacharya* also described the disease as one of the *lakshana's* of *Revati graha* [10]. The *Revati graha* has synonyms like *Shasthi*, *Mukhmandika*. *Acharya* advised to worship *shasthi maata* on 6th day after birth of child (neonatal period). This make clear that it can affect the neonate by producing symptoms like Neonatal jaundice.

Virechana (purgation) has been considered as the best treatment according to *Kashyapa* in *Pittaja Stanya dushti*. For "*Daugandhya Dosh*" (a type of *Pitta* vitiated breast milk) use of *Vishanika*, *Ajashringi*, *Triphala*, *Rajani*, *Vacha* with cold water is indicated.

There are two references in classical texts of *Ayurveda* where the jaundice in newborn can be considered-

a) Pishachi Jataharini [10]: In which the newborn dies immediately after birth and is a *mamsahari yaya jataharini*. The word *Pishachi* in *shabdakosha* has been given the meaning as a demon which has characteristic yellow color that kills the baby on first day itself can be considered as the pathologic neonatal hyperbilirubinemia.

b) Paittika stanya dushti janya kamala: *M. nidana* has explained that if a baby takes *pitta dushta stanya* (vitiated milk), he exhibits the features like excessive sweating, loose stools, *kamala roga* (jaundice), thirst and increased body temperature. *Charaka Acharya* explains *daugandhya* (fetid smell) and *vivarnata* (discoloration) as the features of *pittaja ksheera dushti* (*Pitta* vitiated breast milk) [11].

2.3. Stanya dushti – a source for neonatal hyperbilirubinemia

Milk is defined as the essence of *Rasa dhatu* (plasma), which in turn depends on the diet and its assimilation in the mother. A *navajata shishu* (newborn) is dependent on to his mother for the food and nutrition. Therefore, breast milk if gets vitiated by the *doshas* (body humors), manifests various diseases as per the predominance of the *doshas*. The causes of vitiation of milk can be due to the defective dietetic intake in quality and quantity in the mother (Excessive use of *snigdha* (unctuous), *abhishyanda* (food which increases *kapha*) and *guru* (heavy) substances like *paayasam* or over intake of *katu* (spicy), *amla* (sour), *lavana* (salty) and *kshara* (alkali) substances) and also due to the defective eating habits and impaired digestion in mother [12]. *Kashyapa* describes number of *grahas* also to vitiate milk: *Shakuni* making the milk acrid and bitter and *Pootana* bring sweet and acrid taste in milk.

2.4. Pittaja stanya dushti-an origin to neonatal hyperbilirubinemia

Milk vitiated by *Pitta* either gets discolored (*Vivarnata*) or acquires a disagreeable fetid smell (*Durgandha*) with more waste metabolites or decomposed, as though, the milk is kept at room temperature for long time. "*Acharya Charaka*" stated- The diseases of children and that of adults are quite similar but the difference is only in the *dosha dushya*, which are in smaller quantity than that of the adult [12]. Hence, the disease will be reviewed as per *Charaka's* description for adults in consideration for the neonates. In *Ayurveda Pandu roga* (anemia) and *Kamala* are described together [12]. Stage 1- *Pandu* (5 types of *Pandu* according to *dosha pradhaanata* (predominance of body humors) explained by *Charakacharya*).

In above mentioned conditions, or even without *Pandu roga* (anemia) when one indulges in *Ateeva Pittavardhaka Ahara* (food that causes *Pitta* vitiation), *kamala* (jaundice) ensues in stage 2 (a) *Vataja pandu* with added *Pitta* produces *Haleemaka*; (b) *Pittaja pandu* with added *Pitta* produces *Kamala* and (c) *Kaphaja Pandu* with added *Pitta* produces *Kumbhakamala*.

Table 2
Showing *lakshana* (Clinical features) of different stages of *Kamala*

Clinical features	<i>Koshthashrita</i>	<i>Shakhashrita</i>	<i>Halimaka</i>	<i>Kumbha kamala</i>	<i>Lagharaka and Alasa</i>	<i>Panaki</i>
<i>Haridra Netra</i>	Yes	Yes	Yes	No	No	No
<i>Haridra Twak</i>	Yes	Yes	No	No	No	No
<i>Haridra Nakha</i>	Yes	No	No	No	No	No
<i>Haridra Mukha</i>	Yes	No	No	No	No	No
<i>Haridra mutra</i>	No	Yes	No	No	No	No
<i>Rakta Peeta Mutra and Pureesha</i>	Yes	No	No	No	No	No
<i>Sweta varcas</i>	No	Yes	No	No	No	No
<i>Tila -pishtanibha varcas</i>	No	Yes	No	No	No	No
<i>Krishna Peeta Pureesha & Mutra</i>	No	No	Yes	Yes	No	No
<i>Jvara</i>	Yes	No	No	No	Yes	Yes
<i>Aruchi</i>	Yes	No	Yes	Yes	Yes	No
<i>Daha</i>	Yes	No	No	Yes	No	No
<i>Daurbalya</i>	Yes	Yes	Yes	No	No	No
<i>Shotha</i>	No	No	No	Yes	No	No
<i>Angamarda</i>	No	No	No	No	Yes	No
<i>Bhrama</i>	No	No	Yes	No	Yes	No
<i>Kshaya</i>	Yes	No	Yes	No	Yes	No
<i>Pandu Netra</i>	No	No	No	No	No	Yes
<i>Sarakta Netra</i>	No	No	No	Yes	No	No
<i>Sarakta Pureesha</i>	No	No	No	Yes	No	No
<i>Sarakta Mutra</i>	No	No	No	Yes	No	No
<i>Shwasa</i>	No	No	Yes	Yes	No	Yes

3. Etiopathogenesis

Severe depletion of 'Ojaso gunaah' (essence) in body (like *bala*, *varna*, *sneha* etc.) leads to *alpa rakta* (anemia), *alpa meda* (loss of fat) and *nissara* (less essence) which in turn causes *shithila indriya* (weakness of the sense organs) [12]. Such child attains *vaivarnata* (discoloration) of skin like *pandu* (pallor), *haridra* (yellow), *harita varna* (green color). The depletion of *ojo guna* (essence of body) occurs due to 3 group of causes:

1. Group 1: Depression of RBC synthesis (dyshaemopoietic) due to excess intake of *lavana*, *katu* and *Kashaya rasa* (astringent taste)-can be considered in terms of *dushta stanya paana* (intake of vitiated milk) [13] and Pica/mud eating-cannot be considered in neonatal hyperbilirubinemia.
2. Group 2: Vitiating of *Pitta pradhana doshas* and *dhatus* (*Pitta* predominant body humors and tissues) leads to *gauravam* (heaviness) and *shithilata* (loosening) of that particular *dhatu* which further leads to depletion of *ojo guna*. Various metabolic and hemolytic causes are *Maireyamadya sevana* (alcohol intake) (cannot be considered in neonatal hyperbilirubinemia) and *Daugandhya stanya sevana* (*Pittaja stanya dushti*).
3. Group 3: Various hemorrhagic conditions leads to *rakta kshaya* (depletion of blood)-cephalhematoma and sub-galeal hemorrhage in newborn can be considered. In conditions where there is depletion of *ojoguna*, if one indulges in *Pittavardhaka ahara*, *Vayu* through the ten *dhamanees* (blood vessels) brings and lodges the *pitta* in *twak* (skin), *mamsa* (muscle) and *rakta*. This *pitta* burns these *dhatus* and produces different *kamala* (based on *dosha*). Thus *kamala* can occur in two ways: (a) Excessive *Pitta* in *Pandu- Koshthashrita* or *Shakhashrita kamala*. (b) Without *Pandu roga* also as *Pittolbana* (due to increased *Pitta*) Therefore, *Kamala* is *Pitta dosha pradhana vyadhi*.

3.1. *Koshthashrita kamala* and *Shakhashrita kamala* in relation to neonatal hyperbilirubinemia

Koshthashrita kamala: Pandurogi (anemic) or by ingestion of *Pittakara Ahara-Vihara* leads to *Pittaprakopa* (excessive vitiating of *Pitta*). That Vitiating *Pitta* produces *Vidaha* (burning) of *Mamsa* (muscle tissues) and *Rakta* (blood). Vitiating *Pitta* gets accumulated

in liver and then spread all over the body causing *Bahupitta Kamala* (hyperbilirubin) or *koshthashrita Kamala* [12]. In *Koshthashrit KamalaPandu rogi* (anemic) and or *Pittolbana* (having excessive *Pitta*) person who ingests *Pittaja Ahara-vihara*, *Pitta* aggregates and produces *kamala* (jaundice). For this, specific causes like *Dadhi sevana* (curd) [14], *Dushta stanya sevana* (vitiating milk intake) [15], *Raktavaha Strotodushti* (vitiating of the blood channels), *Katurasa sevana* (spicy food) [16] are mentioned.

In *Koshthashrita Kamala*, the excessive *Pitta vridhi* (increased *pitta*) due to all the above mentioned *nidana* (causes), produces abnormality in the *Raktavaha srotas* (blood channels) and *Raktavaha srotomula* (origin of blood channels), *dosha dushyasammurchana* (pathogenesis) occurs in liver. Then *ati pravriti* (excessive flow) of *pitta* occurs through *pitta vaha srotas* (channels carrying *Pitta*) into the *koshtha*, resulting in the dark yellow coloration of urine and stool. Vitiating *vata* also causes *ati-pravriti* of *pitta* in *Rasa-Rakta* etc. *Dhatus*. So when this *vridha pitta* reaches the sites of the clinical manifestation of *Kamala* disease via *Rasa-Rakta Dhatus*, it produces yellow coloration just like that of *Haridra* (turmeric/yellow color) in these sites i.e. in eyes skin, face nail, urine etc. which is the cardinal signs of *Kamala* [17]. *Nidana* of *Kamala* explained by *Acharya Charaka* and *Madhavakara* as *dushtya Stanyapana* (intake of vitiated milk) by the baby which leads to *navajata Kamala* (neonatal hyperbilirubinemia). In modern science, it can be compared with the mechanism of pre hepatic jaundice or Haemolytic jaundice in which more bilirubin is found in blood due to excessive destruction of RBC and is not excreted adequately by liver resulting in hyperbilirubinemia responsible for various symptoms like yellow discoloration of eye, skin etc.

Shakhashrita kamala: Here, Vata and Kapha prakopa takes place due to ingestion of *Kapha* and *Vata* vitiating factors. When vitiating *Vata* get combines with vitiating *Kapha*, causing obstruction in biliary canaliculi, *Pitta* does not enter into the intestine and gets accumulated in liver. The excessive accumulation of *Pitta* in liver spreads all over the body except intestine, hence causing clay color stool i.e. *Tilpishtanibha Malapravratti* (stools like sesame paste) and yellowish discoloration of *Nakha* (nails), *Netra* (eyes), *Twak* (skin), *Mutra* (urine). This is called as *Shakhashrita* (at the periphery) or *Rudhapatha Kamala* (obstructive jaundice). In *Shakhashrita Kamala Nidanans* are *Kapha* and *Vata* vitiating factors like intake of food having predominantly *Sheeta Guna* (cold), *Guru guna*, *Madhura rasa* (sweet), *Rooksha guna* (dry), *Ativayayama* (excessive exercise),

Vegadharana (suppressing natural urges) etc. In obstructive jaundice, same mechanism can be observed in which the bile ducts are obstructed by gall stone or other causes and bile is accumulated in liver, resulting in elevation of blood bilirubin level responsible for yellowness of eye, skin, mucous membrane and stool become clay colored due to lack of bile in the intestine. In Hepatocellular jaundice, when there is complete obstruction of all the bile canaliculi due to their compression by edematous hepatocytes, jaundice is produced just like *shakhashrita Kamala*. When there is incomplete obstruction or when all the bile canaliculi are not obstructed then it is produced like that of *koshthashrita Kamala*.

3.2. Physiology in relation to neonatal hyperbilirubinemia

Raktotpatti (Erythropoiesis): *Rakta Dhatu* (blood) is stated to be formed from *Rasa Dhatu* (plasma) through *Dhatu Parinama karma* (formation of body tissues). The *Dhatuparinamana*, regular nourishment of the *Dhatu*s of the body, comprise of *two pakas* [18]. (a) *Prasada paka* (nourishment)-Leads to production of 7 type of *Prasada dhatu*. (b) *Kitta paka* (waste)-Leads to production of *kitta* or *mala* of respective *dhatu*. Three factors participating in *parinama* of *Rasa dhatu* to *Rakta dhatu*, are *Rasagni* (fire of plasma), *Raktagni* (fire of blood) and *Ranjakapitta* [19]. *Rasa* and *Raktaagni* act on *Ahara Rasa* and leads to formation of *Prasad* (*Rasa* and *Rakta dhatu* respectively) and *Kitta bhaga*. i.e. *Pitta* (*Ranjaka Pitta*).

During the process of *Dhatuparinama* (transformation of the tissues), *Dhatwagni* (factors responsible for tissue transformation) leads to the formation of *Raktajeevaparmamu* (elements of blood). *Raktavaha strotas* and *Raktadhara kala* both helps in formation of *Rakta Dhatu* and *Yakrita* is the *moola* (site of origin). But *ranjana karma* (providing color) of *Rakta* is done by *Ranjaka pitta* situated in *Yakrita* (liver), *Pliha* (spleen), and *Amashaya* (stomach) produced from *poshaka Rakta* as a *malarupa* [20]. As *kamala* (jaundice) is a *Rakta pradoshaja vyadhi* (disorder due to vitiation of blood) having *Raktavaha stroto vikara* (vitiating in blood channels), so *Yakrita* (liver) and *Pleeha* (spleen) are also important factors involved in the *samprapti* (pathogenesis) of the disease *Kamala*.

Relation between *Dosha* (body humors) and *Yakrut* (liver): *Pitta dosha* is formed in *Yakrita*. It is the primary place of *Ranjaka Pitta*. This is the factor involved for the formation of *Rakta dhatu* (blood) from *Rasa dhatu* (plasma). Therefore, here the hemolysis of the RBC's can be considered giving rise to the production of bilirubin.

Relation between *Dushya* (body tissues) and *Yakrut* (liver): *Yakrita* is formed from *Rakta Dhatu* and it is the *moola sthana* of *Raktavahastrotas* [21]. Formation of *Rakta Dhatu* takes place in *Yakrita*. According to the consideration of *Acharya Sushruta* and *Vagbhata*, the *Yakrita* is derived from the *accha* (pure) portion of the fetal blood [22]. Hence, the structure is soft, well organized and secretary in nature. It secretes *Pachaka pitta* that is stored in the *Pittashaya* (duodenum) or the gall bladder. The concentration of *Pitta* is very important. If the concentration alters, it leads to lot of diseases arising out of *Agnivaishamyaya* (vitiating of digestive fire). Here, *Yakrita* can be compared with the organ Liver of the contemporary medicine.

Pitta (*Malarupi*): *Tejas* (fire element) is present in the form of *Agni*, which is present in our body in the form of *Pitta* [23]. Manifestation of yellow color to body is due to *Pitta vruddhi* which is due to *tejo mahabhuta* (fire element). *Kamala* is a disease which is due to *Pitta vruddhi*. Hence, vitiation of *pitta* and *agnivaishamayata* (impairment of digestive fire) affect each other and vice versa. *Moolasthanas* of *Raktavaha strotas* *Yakrita* and *Pleeha*. Therefore, it can be understood that *utpatti* of *malarupipitta* (bile) takes place in *Yakrita* with the help of *Raktagni*. Because of *samana guna* (same properties) of *Pitta* and *Rakta*, *Pittare* main along with *Rakta* in *ashrayashrayi bhava* (association) [24]. When *agnivaishamyaya* (impairment in the digestive fire) happens in the body, then it produces *malarupi pitta* in

larger quantity which is stored in *yakrita* and circulated all over the body and gives *vikruta varna* (discoloration) to the body.

4. Clinical features of Kamala

4.1. Pathogenesis of neonatal hyperbilirubinemia in the view of Ayurveda

Due to the *Nidana sevana* (causative factors), *Pitta pradhana tridosha* (*Pitta* predominant body humor) gets aggravated, which in turn vitiates the *Rakta dhatu* (due to *ashraya ashrayi sambandha*). After *Rakta dhatu* (blood) getting vitiating, the *moola* of *Rakta dhatu* i.e. *Yakrut* and *Pleeha*, also gets vitiating and therefore, the *Rakta dhatu kshaya* (decreased blood) takes place (both in quality and quantity-quality is maintained by the *yakrut* by doing the *ranjana karma* which can be compared with the conjugation of the unconjugated bilirubin → gets hampered; *Pleeha* maintains the quantity of *rakta dhatu* which can be compared with the early lysis of the RBC's). This leads to the *shithilata* (impairment) of the *Rakta and Mamsa dhatu* and therefore, the aggravated *pitta* due to *atipravritti* (excessive movement) and *vimargagamana* (movement in opposite direction), takes *sthana samshraya* (location) at *tvak* (skin), *rakta* (blood) and *mamsa dhatu* (muscle tissues) and manifest as Neonatal hyperbilirubinemia (Fig. 1).

Samprapti Ghataka (factors responsible for pathogenesis) [25].

1. *Dosha*: *Pitta*
2. *Dushya*: *Rakta, Mamsa*
3. *Adhithana*: *Koshta* (*Mahasrotasa – Yakrit*), *Shakha* (*Raktadi and tvacha*)
4. *Srotas*: *Rasavaha, Raktavaha, Annavaha, Pureeshavaha*
5. *Srotodushti*: *Atipravritti* (excessive production), *Sanga* (obstruction), *Vimargagamana* (moves in opposite direction)- (In physiologic neonatal hyperbilirubinemia, *atipravritti* and *vimargagamana* can be considered whereas in pathologic neonatal hyperbilirubinemia, *sanga, atipravritti* and *vimargagamana* can be undertaken).

5. Prognosis

While describing the disease *kamala* of the *Acharyas* have mentioned its *Sadhya-Asadhyatva*, whereas almost all the *Acharyas* has mentioned that negligence or improper management of *Kamala* leads to complications which can be taken as the conditions like kernicterus, brain encephalopathy, choreo-athetoid cerebral palsy in the contemporary science. *Ayurvedic* classics mentioned the following as the *Asadhya lakshanas* (untreatable symptoms) of *kamala*, indicating bad prognosis like *Krishnapeeta mutra* and *shakrit* (dark yellow colored urine and stool), *Atishotha* (edema), *Raktaksita* (redness of eye), *Raktamutra* (hematuria), *Daha* (burning sensation), *Aruchi* (loss of taste), *Trishna* (thirst/dehydration), *Anaha* (indigestion), *Tandra* (tiredness), *Nashtagni* (loss of appetite), *Nashta Sangya* (unconsciousness) etc.

So, *Kumbha kamala* can be compared with that of the Kernicterus explained in modern science as the complication of neonatal hyperbilirubinemia.

6. Treatment

There is no direct reference of *Navajata Kamala chikitsa* (neonatal hyperbilirubinemia) in *Ayurveda*, but, as the *nidana* for *navajata kamala* is considered to be *pittaja stanya dushti*, which is consumed by the baby, *pittaja stanya dushti chikitsa* is taken as the line of treatment. Generally correction of vitiating milk brings forth normalcy in the child in mild cases. In severe cases, the child can be

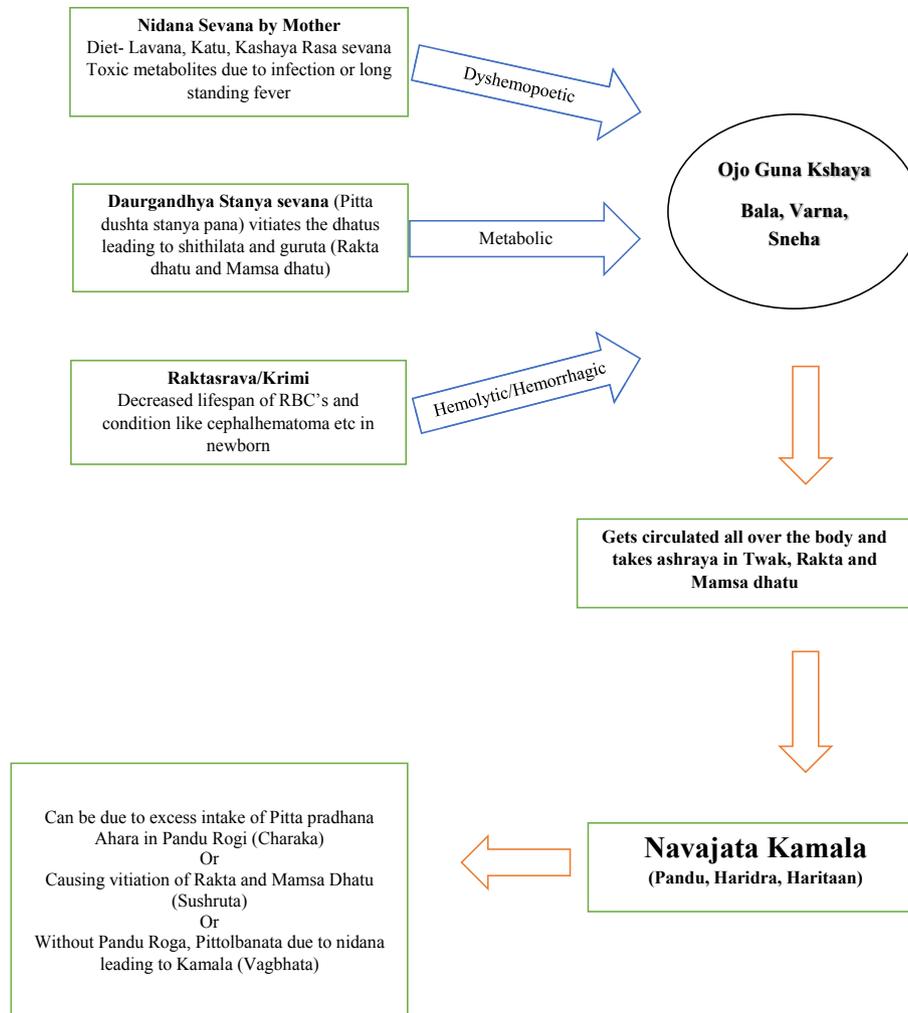


Fig. 1. Pathogenesis of neonatal hyperbilirubinemia through Ayurveda.

administered medicine depending on the vitiated *dosha*. *Sushruta* in *chikitsa sthana* advocates induction of vomiting to the mother irrespective of the vitiated *dosha* in milk. *Charaka* though advocates induction of both vomiting and purging in *chikitsa sthana* 30th chapter, advises one or more of the four means of commingling i.e. of *Vamana* (vomiting therapy), *Virechana* (purgation therapy), *Asthapana* and *Anuvasana* (enema therapy), depending on the *doshas* vitiated [12]. Thus, the principles of treatment of vitiated milk disorder can be classified as follows:

6.1. In mother

General measures taken are (a) Extirpation of the vitiated humor by induction of vomiting irrespective of the *Dosha* with oral use of the decoction of *Nimba* with honey and *Pippali* as advised by *Sushruta* [12]. (b) *Pathya Bhojana* [26]. (c) Internal medication to the mother [27] consists of combination of different drugs selected from among the groups of *Dosha shaman* (*dosha* pacifying) drugs, *Stanya vishodhana* drugs (which treats the vitiated breast milk), *Stanya vardhana* (which increases the breast milk formation) drugs.

Specific measures are described in the form of local application to the breasts, in various types of milk vitiations, along with internal medication. In cases of distasteful milk, the mother is made to drink the paste of *Draksha*, *Madhooka*, *Sariva* and *Ksheerakakoli* in water. A paste made of *Panchakola* and *Kulattha* is applied on the

breasts which when dries off is washed out and the existing milk is removed with a breast pump. The milk that flows later is pure and can be safely given to the infant [12]. Foamy milk can be purified by making the mother take the paste of *Patha*, *Naagara* and *Moorva* in water. The existing milk in breasts is taken out after applying a paste of *Anjanam*, *Shunthi*, *Devadaru* and *Priyangu* to the mammary glands. Alternatively, *Kirata*, *Guduchi* and *Shunthi* can be used as decoction for oral use and the paste of *Yava*, *Godhuma* and *Sarshapa* for external use. Non-unctuous milk can be corrected by giving to mother, the decoction of *Stanyas hodhaka* drugs according to availability and by the application of a poultice made of *Panchamoola* and *Jeevaneeya* drugs. As usual, the poultice when dries is washed off and the milk is extracted. The milk that accumulates further, becomes pure for the infant to feed. When milk becomes discolored with *Pitta*, the mother is given with the paste of *Yash-timadhu*, *Draksha*, *Payasya* and *Sindhuvara* in cold water to drink and a poultice of *Draksha* and *Yashti* is applied over the mammary glands. Repeated extraction of milk after the poultice gets dried and when washed off, brings normal color to the milk. Deodorization of disagreeable odor in milk is achieved by oral administration of either the paste of *Vishanika*, *Ajashringi*, *Triphala*, *Rajani* and *Vacha* in water; or the powder of *Abhaya* and *Trikatu* in *Manjishtha*, *Shleshmataka* and *Chandana* or *Usheera* applied to the breasts in similar fashion makes the milk free from disagreeable smell [12]. Excessive viscosity can be removed by oral administration of paste

of *Daru*, *Musta* and *Patha* to which *Saindhava* is added. Slimy milk can be made good by oral use of *Takrarishtha* or of *Abhaya*, *Vacha*, *Musta*, *Shunthi* and *Patha*. A poultice made of *Vidari*, *Bilva* and *yashti* is applied to the mammary glands in both the conditions and milk is removed [12]. Heavy milk can be made light by oral use of either the decoction of *Trayamana*, *Amrita*, *Nimba*, *Patola* and *Triphala* or the paste of *Pippalimoola*, *Chavya*, *Chitraka* and *Shunthi*. A poultice made by *Bala*, *Shunthi* and *Moorva* or of *Prishnaparni* and *Payasya* applied to the breasts and washed after it becomes dry makes the milk light [12].

6.2. In child

In mild cases, no treatment to the child is required and hence *Sushruta* and *Agnivesha* do not advocate treatment for the child normally when vitiated milk is sucked. The ailment becomes corrected with the treatment of the mother alone. However, *Vagbhata* gives description of treatment to the child and this should be applied when humors get vitiated more. When milk becomes vitiated with Vayu, the child is given the powder or ghee prepared of *Rasna*, *Ajamoda*, *Sarala* and *Devadaru* to which sugar may be added [28]. In *Pittaja* milk disorder, the decoction of *Amrita*, *Abheeru*, *Patola*, *Nimba*, *Chandana* and *Sariva* can be given to both, the mother and the child [29]. After applying the paste of *Raathapushpa* to the nipple and areola, the child is made to suck it without being washed to bring forth an easy emetic effect in cases of vitiation of milk by *Kaphadosha* [12].

6.2.1. Anulomana and mruduvirechana

In *Kamala vyadhi*, *Virechana* is the main treatment. In *pittaja vikara* also, the main principle of treatment is *Virechana*. *Acharyas* mentioned *anulomana* (correcting the direction of *Vata*) and *Mrudu virechaka* drugs for *virechana karma* in *Kamala* and *Pittaja Vikaara*. In *Balaka*, *Virechana* like *Panchakarma* is contraindicated but *Mruduvirechana* (mild purgative therapy) and *Anulamana karma* are mentioned [30]. The following formulations mentioned under the disease *Kamala* (Jaundice) as mentioned in classics can be tried in newborns in an appropriate and palatable form (Table 3).

Table 3
Showing *Shamanaushadhis* in *Kamala vyadhi*.

Single drugs	
	<i>Amrita Swarasa</i> <i>Bhunimbamalagi Swarasa</i> <i>Daruharidra Swarasa</i> <i>Nimbapatra Swarasa</i>
Compound drugs:	
A. <i>Churna</i>	<i>Navayasa Churna</i> <i>Bhunimbadi churna</i> <i>Jeevantiyadi Churna</i> <i>Phalatrikadi kwatha</i>
B. <i>Kwatha</i>	<i>Vasadi kwatha</i> <i>Darvyadi lehya</i>
C. <i>Avaleha</i>	<i>Triphaladi Avalehya</i> <i>Drakshadi lehya</i> <i>Vidanga Lehya</i>
D. <i>Rasaoushadhi</i>	<i>Swarnamakshika</i> <i>Vidangadi Loha</i> <i>Punarnava Mandura</i> <i>Mandura bhasma</i> <i>Dhatri Loha</i>
E. <i>Ghritas</i>	<i>Kalyanaka Ghrita</i> <i>Mahatiktadi Ghrita</i> <i>Panchagavya Ghrita</i> <i>Pippalyadi Ghrita</i> <i>Trayushanadi Ghrita</i>

7. Role of MRP 2 molecule and mode of action of drugs

The pharmaceutical action of the ayurvedic drugs can be understood in two ways i.e. increasing the uptake of the unconjugated bilirubin for its conjugation by the hepatocytes, enhancing the transportation of the conjugated bilirubin to the intestine and then the excretion of the conjugated bilirubin [31]. The increase in the uptake, conjugation and its transport can be understood by the role of MRP 2 molecule. The multi-drug resistance protein MRP2 is an ATP-binding cassette transporter playing an important role in detoxification by transporting a wide range of compounds, especially conjugates of lipophilic substances with glutathione, glucuronate and sulfate, which are collectively known as phase II products of biotransformation. In addition, MRP2 can also transport uncharged compounds in cotransport with glutathione, and thus can modulate the pharmacokinetics of many drugs. For the excretion of the conjugated bilirubin, the *rechaka* (purgative) property of the drug helps to prevent the rise of serum bilirubin level. The above mentioned drugs for the treatment of *Kamala* act upon the uptake of unconjugated bilirubin by the hepatocytes, stimulating the MRP 2 protein molecule for the quick transport of the conjugated bilirubin for its excretion by the *rechaka* property. The drugs by their *Pittahara* and *rasayana* (rejuvenative) property help in reducing the formation of *malarupi Pitta* (bile) and also in the regeneration of the *yakrut* (hepatocytes) for its uptake. The antioxidant, antimicrobial and immunomodulatory property of the drugs help in scavenging the free radical stress, thereby, prevent the rise in the level of bilirubin.

8. Conclusion

The concept of neonatal hyperbilirubinemia in *Ayurveda* can be understood in the context of *Pittaja stanya dushti* along with the physiological variations in the newborns leading to the raised level of unconjugated bilirubin. Therefore, the patho-physiology should be known by a pediatrician in *Ayurveda* based on the involvement of *dosha*, *dhatu*, *mala* and *srotas*. The standard treatment principle mentioned in the contemporary science as phototherapy has its own side-effects [32]. Therefore, *Ayurvedic* pediatricians should bring forth formulations to prevent the rise of bilirubin to an extent to cause complications like kernicterus etc.

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